Reprinted from The Journal of the American Medical Association
June 20, 1953, Vol. 152, pp. 673-676

SUCCESSFUL RESECTION OF ANEURYSM OF THORACIC AORTA AND REPLACEMENT BY GRAFT

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Various procedures have been used in the surgical treatment of intrathoracic aortic aneurysms. These have been recently reviewed [1] and classified as follows: (1) those designed to promote thrombosis and fibrotic organization of the process by ligation, introduction of foreign material, or periarterial fibroblastic reaction; (2) endoaneurysmorrhaphy; and (3) extirpation of the lesion with or without restoration of blood flow through the parent vessel. With the exception of the last method, most of these procedures have proved generally unsatisfactory. Obviously the procedure of choice is extirpation of the diseased part and restoration of normal function, but this has been successfully accomplished in only a relatively small number of cases of sacciform aneurysms [1] or those associated with coarctation.[2] So far as we have been able to determine, there are no reports of its successful application in a case of fusiform aneurysm of the thoracic aorta. It seems desirable, therefore, to report the following case of a syphilitic aneurysm of the descend-

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The work in this case was aided by a grant from the Houston District Chapter of the Texas Heart Association.

1. Cooley, D. A., and De Bakey, M. E.: Surgical Considerations of Intrathoracic Aneurysms of Aorta and Great Vessels, Ann. Surg. **135**: 660, 1952.

2. (*a*) Gross, R. E.: Treatment of Certain Aortic Coarctations by Homologous Grafts: Report of 19 Cases, Ann. Surg. **134**: 753, 1951. (*b*) Shumacker, H. B., Jr.: Coarctation and Aneurysms of Aorta: Report of Case Treated by Excision and End-to-End Suture of Aorta, ibid. **127**: 655, 1948. (*c*) Swan, H.; Maaske, C.; Johnson, M., and Grover, R.: Arterial Homografts: Resection of Thoracic Aortic Aneurysm Using Stored Human Arterial Transplant, Arch. Surg. **61**: 732 (Oct.) 1950.

ing thoracic aorta that was successfully resected with restoration of normal blood flow by means of an aortic homograft.

REPORT OF A CASE

A 46-year-old white man was admitted to the Methodist Hospital on Dec. 31, 1952, complaining of lower back, left lower abdominal, and inguinal pain of three months' duration. The pain began spontaneously, and at the outset occurred in episodes necessitating hospitalization on several occasions. For the previous few weeks and on admission to this hospital, the pain was constant, sharp, and severe and was partially relieved by lying on the left side. For adequate relief, however, opiates or meperidine (Demerol) was required as often as several times daily. Barium studies of the upper gastrointestinal tract and roentgenograms of the thoracolumbar spine made at the Hertzler Clinic in Halstead, Kan., were interpreted as showing an aneurysm of the terminal thoracic and proximal abdominal aorta producing erosion of the vertebral bodies at the level of the diaphragm. The patient gave a history of treated syphilis. A cholecystectomy had been done five years previously.

Physical examination revealed a well-developed, anxious man who appeared chronically ill. The pulse was regular, and the blood pressure was 140/80 mm. Hg. The heart was not enlarged, and there were no unusual sounds or murmurs. There was a well-healed subcostal incision on the right side of the abdomen, and no organs, masses, or hernias were palpable. Deep palpation in the left lower quadrant of the abdomen and over the left inguinal ligament elicited pain, but there was no paresthesia or hyperesthesia. Likewise, palpation over the lumbosacral region was painful, but there was no specific localization. The findings on neurological examination, including tendon reflexes, were normal. Circulation in the lower extremities was good. Although the posterior tibial pulses were not palpable, the dorsalis pedis pulses were strong and the feet were warm.

Laboratory findings revealed an erythrocyte count of 5.17 million, hemoglobin level of 16.9 gm. per 100 cc., and white blood cell count of 10,000, with 80% segmented neutrophils, 3% band forms, 14% lymphocytes, and 3% monocytes. The Kahn serologic test for syphilis was doubtful, and the Kolmer test was negative. The urine was dark amber with a specific gravity of 1.033 and an acid reaction. There were 35 mg. of protein per 100 cc., a trace of sugar, and some acetone. There was no diacetic acid, and microscopic examination disclosed no abnormal findings. The blood urea nitrogen level was 14 mg. per 100 cc., and the prothrombin activity was 100% of normal. An electrocardiogram revealed no abnormality.

Roentgenographic studies of the chest revealed the heart and lungs to be normal, but a large mass was visible behind

the heart and arising at about the diaphragm. Lateral projections of the thoracolumbar vertebrae in the region of the mass revealed extensive erosion of the bodies of the 9th, 10th, 11th, and 12th thoracic vertebrae and the first lumbar vertebra; they were most marked at the 11th and 12th thoracic levels (fig. 1). The intervertebral bodies were not eroded. Fluoroscopy revealed a pulsatile mass measuring about 20 by 15 by 15 cm. behind the heart. The mass appeared to be continuous with the lower thoracic aorta and displaced the esophagus and

Fig. 1.—Lateral roentgenogram of the lower thoracic vertebrae showing extensive erosion of the vertebral bodies from the ninth thoracic to the first lumbar vertebra.

stomach anteriorly and to the left. Results of an excretory urogram were normal.

On Jan. 3, 1953, with the patient under thiopental (Pentothal) anesthesia, aortography was performed by insertion of a no. 10 French woven catheter into the left brachial artery and threading of the catheter under fluoroscopic control into the midthoracic aorta. Then 30 cc. of 70% iodopyracet (Diodrast) solution was injected rapidly, and a single film was

exposed. The aorta and the extensive aneurysm were moderately opacified. The aneurysm was demonstrated to have a layer of clot on both sides, represented by a nonopacified rim of tissue. The aorta was displaced to the left by the aneurysm, which presented primarily on the right and posteriorly. Multiple intercostal arteries were visualized as well as branches of the celiac axis (splenic and hepatic arteries), both renal arteries, and the superior and inferior mesenteric arteries (fig. 2).

Operation.—On Jan. 5, 1953, anesthesia was induced by ether administered by tracheal intubation, the patient was placed in a 45 degree right lateral position, and the pleural cavity was entered through the bed of a resected segment of the ninth rib (fig. 3*A*). The lung was retracted forward, and

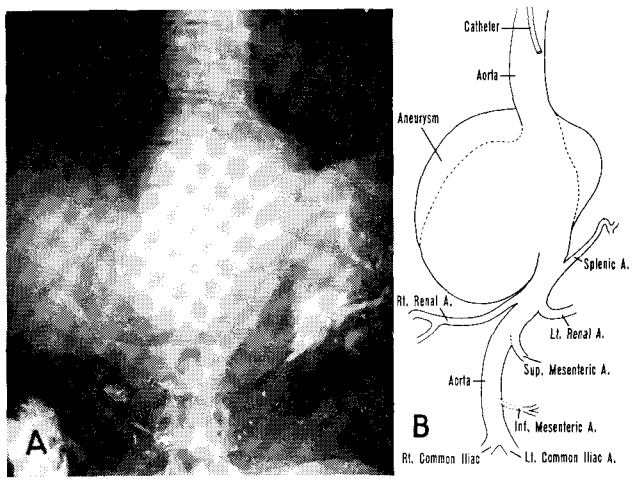

Fig. 2.—*A*, aortogram showing aneurysm of descending thoracic aorta. *B*, diagrammatic representation of the aortic tributaries and the involved structures.

the aneurysm was exposed. The lower thoracic aorta arched anteriorly on the proximal margin of the aneurysm, which appeared to be about 20 cm. in length and 20 cm. in its greatest diameter. It was firmly adherent to the vertebrae posteriorly. The mediastinal pleura was incised over the proximal aorta, and the aorta was encircled with an umbilical tape. In order to expose the distal portion of the aneurysm, the thoracotomy incision was extended obliquely across the upper abdomen, dividing the costal margin. The diaphragm was incised, and the esophageal and aortic hiatuses were opened. The spleen was removed to facilitate exposure. Inferiorly the aorta was encircled just distal to the celiac axis but proximal

to the renal and superior mesenteric arteries. At this point the aorta was only adherent to but not involved in the aneurysm itself (fig. 3*B*). Atraumatic arterial clamps were then used to occlude the proximal and distal aorta after injection of 10 mg. of heparin solution, and the celiac axis was occluded

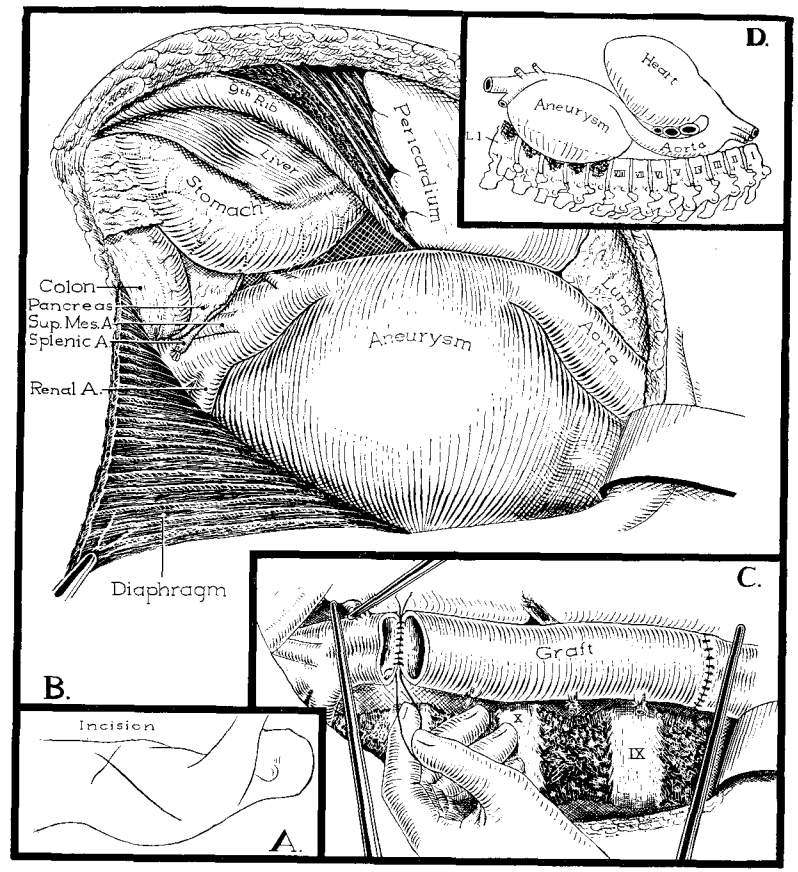

Fig. 3.—A, position of patient and placement of incision. B, anatomical relationships of the aneurysm to the thoracic and abdominal viscera. C, method of occlusion of proximal and distal aorta during aneurysmectomy and insertion of the aortic homograft. The anastomosis was performed by a continuous through-and-through suture. D, representation of the aneurysm showing the relative position and size of the sac and eroded vertebral bodies.

separately (fig. 3*C*). The aneurysm was dissected off adjacent structures anteriorly and partially excised in order to provide adequate space for the homograft.

An aortic homograft measuring approximately 15 cm. in length was simultaneously prepared to bridge the defect. The graft had been originally obtained six days previously from a 21-year-old Negro man who had died of acute injuries. The graft was obtained under sterile conditions two hours after the donor died and was kept for 36 hours in sodium chloride solution containing 1 gm. of streptomycin and one million units of penicillin. The graft was transferred to Gross's medium, to which no serum had been added, and stored at 4 C. By a continuous through-and-through suture of 4 0 arterial suture the graft was anastomosed to the proximal and distal ends of the aorta (fig. 3*C*).

The blood pressure, which prior to aortic occlusion was 140/100 mm. Hg, rose promptly to 200/100 after the occlusion. The pressure decreased to 160/100 during the 45 minute period that elapsed before the clamps were released after completion of the anastomosis. As the aortic clamps were released very slowly, the blood pressure dropped immediately to 80/60 mm. Hg and remained at that level throughout the remainder of the operation although the patient's general condition appeared good. There was minimal bleeding from the lines of anastomosis, and after a few minutes this stopped completely. The remaining portion of the aneurysm and its contents were then removed and layers of thrombus in varying stages of organization were scooped out piecemeal, leaving the intact intervertebral cartilages protruding forward several centimeters above the eroded vertebral bodies. Because the graft was suspended across the area excavated by the aneurysm, a portion of the omentum was displaced into the thorax and sutured around the graft to protect it from the rather sharp intervertebral bodies posteriorly and to provide a vascular, soft tissue support. The incision in the diaphragm was repaired with interrupted silk sutures, and the thoracoabdominal incision was similarly closed, leaving an intercostal catheter for underwater sealed drainage. During the procedure, which lasted 4 hours and 40 minutes, the patient received 1,500 cc. of whole blood by transfusion.

In the first 24 hour period after surgery the urinary output per Foley catheter was 900 cc. Renal function remained good throughout the patient's hospitalization. Atelectasis of the right upper lobe was demonstrated by roentgenogram on the second day after operation, and this was successfully treated by tracheal aspiration and induced coughing. The postoperative course was otherwise uneventful. The patient became ambulatory on the sixth day after operation, and the sutures were removed on the seventh day. The previous complaint of severe back and left lower abdominal pain was completely relieved, and the patient required no further analgesics. There were no manifestations of cord damage, and the circulation in his extremities appeared much improved. His appetite and

spirits were excellent at the time of discharge from the hospital on Jan. 18, 1953, 13 days after operation, and he resumed his duties as county sheriff approximately one month later.

COMMENT

The only other case in which a somewhat similar procedure was employed was recently reported by Lam and Aram.[3] Their patient also had a large syphilitic fusiform aneurysm of the descending thoracic aorta, but the procedure employed by them differed from that used by us in that the aneurysmal sac was left in situ and an aortic homograft was used to bypass it. The patient died almost three months later from a mediastinal abscess in the aneurysmal sac and secondary hemorrhage. The likely occurrence of such a complication from ischemic necrosis of the sac consequent to its devascularization was pointed out by Tuffier [4] many years ago and emphasizes the importance of extirpation of the aneurysm under these circumstances. This was forcefully impressed upon us by our experience with two previous cases in which fatal hemorrhage occurred from the aneurysmal sac that was not extirpated.[1]

Another important technical consideration in the performance of this procedure is concerned with the potential ischemic hazards of arrest of circulation in the aorta distal to the point of occlusion immediately above the aneurysm, particularly on the spinal cord and the kidneys. The problem here differs from that in coarctation in which a well-developed collateral circulation already exists. To avoid this danger Lam and Aram [3] used a Lucite (polymerized methyl methacrylate) tube over which the homograft was placed to permit blood flow between the two ends of the aorta during the anastomosis. In this way it was hoped to minimize the period of arrest of the circulation, the actual time of occlusion in their case being 24 minutes on one occasion and 15 minutes on another. In spite of this, however, their pa-

3. Lam, C. R., and Aram, H. H.: Resection of Descending Thoracic Aorta for Aneurysm: Report of Use of Homograft in Case and an Experimental Study, Ann. Surg. **134**: 743, 1951.

4. Tuffier, T.: Intervention chirurgicale directe pour un anévrysme de la crosse de l'aorte: Ligature du sac, Presse méd. **1**: 267, 1902; also Bull. Acad. de méd., Paris **85**: 586, 1921.

tient manifested some cord damage, with temporary partial paraplegia. In light of these findings our case is remarkable in that there were no postoperative manifestations of ischemic changes in the cord, the kidneys, or other organs, in spite of the fact that the aorta was occluded for a period of 45 consecutive minutes during which the anastomosis was performed. This would suggest that, at least under some circumstances such as these, the aneurysm may stimulate the development of some collateral circulation or may gradually create in the tissues supplied by this part of the aorta an increased tolerance to a diminished blood supply. The operation of these factors, individually or in combination, may thus be sufficiently effective to maintain viability during the period of occlusion of the aorta required for the anastomosis. Although it is not possible to draw conclusions from a single case, the fact remains that the 45 minute period of occlusion was well tolerated by our patient. This is a matter of considerable importance, however, since the feasibility as well as the facility of the procedure is to a great extent dependent upon it.

In this connection there are several technical features of the procedure that deserve consideration. The first is concerned with minimizing the period of occlusion by leaving the actual extirpation of the aneurysm until after completion of the anastomosis of the graft and release of the occluding clamps. While it may be necessary to excise a part of the sac in order to provide adequate space for placement of the graft, the major portion of the aneurysm and its contents may be removed after restoration of blood flow through the graft. The second point is concerned with the avoidance of thrombosis in the vascular bed distal to the point of occlusion as a possible consequence of the slowing down of the circulation in these vessels. With this objective in mind, a small amount of heparin was injected into the aorta just prior to the application of the occluding clamp. Finally the method of anastomosis employed in our case consisted of a simple continuous through-and-through suture rather than the mattress suture placed so as to fix the intima in an everted position. From our experience with resection and replacement by aortic homografts of abdominal aortic aneurysms, we believe that this method of anastomosis provides equally satisfactory results while at the same time facilitating the performance of the procedure.[5]

It is, of course, too early to determine the ultimate results of this method of surgical treatment of these aneurysms. On the basis, however, of experimental observations on aortic homografts and the clinical results obtained by their use in coarctation,[6] there is reason to believe it provides a better approach to the problem than was hitherto possible. Its ultimate clinical value, as well as certain technical considerations concerned with its performance and the most desirable material for bridging the defect, must await further observation and experience.

SUMMARY

A case is reported of a 46-year-old white man with a huge, probably syphilitic, aneurysm of the descending thoracic aorta producing extensive erosion of the vertebral bodies and incapacitating symptoms. The aneurysm along with the involved segment of aorta was successfully resected with restoration of normal blood flow by means of an aortic homograft. Although the aorta was occluded for a period of 45 minutes during the anastomosis, there were no residual manifestations of ischemic changes in the spinal cord, the kidneys, or other organs.

ADDENDUM

According to a recent letter, dated May 2, 1953, from his local physician, the patient has continued to show progressive improvement with complete relief of symptoms. He has gained 40 lb. (18.2 kg.) since his discharge from the hospital and has returned to work apparently completely recovered.

1200 M.D. Anderson Blvd. (Dr. De Bakey).

5. De Bakey, M., and Cooley, D. A.: Surgical Treatment of Aneurysms of Abdominal Aorta by Resection and Restoration of Continuity with Homograft, Surg., Gynec. & Obst., to be published.

6. Gross, R. E.; Bill, A. H., Jr., and Pierce, E. C., II: Methods for Preservation and Transplantation of Arterial Grafts: Observations on Arterial Grafts in Dogs; Report of Transplantation of Preserved Arterial Grafts in 9 Human Cases, Surg., Gynec. & Obst. **88**:689, 1949. Gross.[2a]

Printed and Published in the United States of America